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Ethnic Inequalities in Periodontal Disease among British Adults

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Abstract

Aim: To explore ethnic inequalities in periodontal disease among British adults, and the role of socioeconomic position (SEP) in those inequalities.

Methods: We analysed data on 1925 adults aged 16 to 65 years, from the East London Oral Health Inequality (ELOHI) Study, which included a random sample of adults living in an ethnically diverse and socially deprived area. Participants completed a questionnaire and were clinically examined for the numbers of teeth with periodontal pocket depth (PPD)≥4mm and loss of attachment (LOA)≥4mm. Ethnic inequalities in periodontal measures were assessed in negative binomial regression models before and after adjustment for demographic (sex and age groups) and SEP indicators (education and socioeconomic classification).

Results: Compared to White British, Pakistani, Indian, Bangladeshi and Asian Others had more teeth with PPD≥4mm whereas White East European, Black African and Bangladeshi had more teeth with LOA≥4mm, after adjustments for demographic and SEP measures. The association of ethnicity with periodontal disease was moderated by education, but not by socioeconomic classification. Stratified analysis showed that ethnic disparities in the two periodontal measures were limited to more educated groups.

Conclusion: This study showed considerable ethnic disparities in periodontal disease between and within the major ethnic categories.

Clinical Relevance

Scientific rationale for study: Despite considerable evidence on ethnic disparities in periodontal disease from other developed countries, no single study has explored whether ethnic inequalities in periodontal disease by ethnicity exist in the UK.

Principal findings: All Asian groups (Pakistani, Indian, Bangladeshi and Asian Others) had more periodontal pocketing whereas White East European, Black African and Bangladeshi had more attachment loss than White British.

Practical implications: Dentists in the UK need to be aware of differences in the development and progression of periodontal disease between and within ethnic groups.

Introduction

Ethnic disparities in oral health have been consistently found in North America, Europe and Australasia, where the predominantly White population exhibits better dental and periodontal health than other ethnic groups (Hjern and Grindefjord, 2000, Dye et al., 2007, Mejia et al., 2010, Elani et al., 2012). The vast evidence on ethnic disparities in adult oral health in other developed countries contrasts sharply with that in the United Kingdom (UK). The latest national Adult Dental Health Survey, carried out in 2009, collected data on ethnicity for the first time since 1969. However, the number of participants from ethnic minority groups was relatively small, making comparisons by ethnic groups unreliable. Oral health inequalities by ethnicity were not published in the survey report (Steele and O'Sullivan, 2011).

Early narrative attempts to summarise the literature have suggested that being a member of ethnic minority groups in the UK does not necessarily correspond to having poorer oral health (Dhawan and Bedi, 2001, Watt and Sheiham, 1999) since oral health was similar among ethnic groups from the same socioeconomic position (Watt and Sheiham, 1999). It is still unknown whether similar patterns are found for periodontal conditions. An early epidemiological study among 15-19-year-old adolescents in the west Midlands of the UK showed that the crude prevalence of juvenile periodontitis was higher in the Afro-Caribbean (0.8%) and Asian groups (0.2%) than in the White group (0.02%) (Saxby, 1987). However, some researchers have argued that collapsing ethnic categories into broader ethnic groups, such as Asians and Blacks, ignores the heterogeneity that exists within broadly defined ethnic groups (Nazroo, 2003, Nazroo and Williams, 2006, Marcenes et al., 2013).

Another important consideration in the study of ethnic inequalities in health is whether these differences are due to race/ethnicity *per se* (genetic make-up) or confounding variables that are related to both ethnicity and health (Dressler et al., 2005, Nazroo, 2003). Previous studies have shown that socioeconomic position (SEP) may fully explain ethnic disparities in periodontal disease because ethnic groups are disproportionately overrepresented in the lower SEP groups (Craig et al., 2001, Craig et al., 2003), while others have reported the persistence of ethnic inequalities in periodontal disease after adjustment for SEP measures (Borrell et al., 2003, Sabbah et al., 2009, Borrell et al., 2004a, Jimenez et al., 2009). Importantly, the composition of ethnic groups varies between countries, precluding any generalisation of former findings to the UK context. It is possible that factors influencing the periodontal status of minority ethnic groups in one country may not be relevant to other settings.

Therefore, the objectives of this study were to first determine whether there were ethnic disparities in periodontal disease among adults in East London (UK), and second, whether SEP measures could explain ethnic differences in periodontal disease.

Methods

Study sample

This article analysed data from the East London Oral Health Inequality (ELOHI) Study which included adults 16 to 65 years old living in Waltham Forest, Redbridge and Barking and Dagenham in 2009-2010. This mixed methods study has been carried out in an ethnically diverse and socially deprived area of London since 2009, aiming to further understand oral health disparities, in particular the barriers, facilitators and pathways between neighbourhood deprivation, oral health behaviours and oral health status. The Outer North East London (ONEL) Research Ethics Committee approved the study protocol (08/H0701/93). Participants who agreed to voluntarily participate provided written informed consent.

Phase 1 of the ELOHI study adopted a cross-sectional study design. A multi-stage stratified random sampling approach was used to select a representative sample of the ethnically-diverse general non-institutionalised population in ONEL. The sampling frame was a list of all addresses stratified by the number of wards in Barking and Dagenham (n=17), Redbridge (n=21) and Waltham Forest (n=20). Fifty-five addresses were randomly selected from each ward to yield 3,193 addresses. Residents were then contacted by post, and invited to participate in the study. Non-respondents were visited to ascertain the household was empty and age of residents. We excluded 457 commercial premises or vacant addresses and 208 ineligible households with no residing adults age 16 to 65 years. The final sampling frame included 2,528 valid addresses and 1,437 households agreed to participate in the study. The household response rate in Barking and Dagenham, Redbridge and Waltham Forest was 61%, 52.2% and 61.2% respectively, which represented a total response rate of 57%.

In order to refine representativeness, a non-respondent household was replaced by a randomly selected household in the same postcode area. Each postcode area includes a small homogeneous population which share the same Index of Multiple Deprivation (IMD). The IMD is a census area-level measure made up of seven domains (income, employment, health and disability, education skills and training, barriers to housing services, crime and living environment). This approach ensured that non-respondents and replacements were comparable as demonstrated by the comparable mean IMD scores in the sample and the

population in 2007, 33.46 and 34.45 respectively, despite of a response rate of 57% (following replacements). A maximum of two adults per household were invited to participate, and all agreed yielding a sample of 2,343 adults who reported their age, gender and ethnicity and participated in at least one part of the survey (Delgado-Angulo et al., 2015).

Data collection

Participants underwent an oral examination and answered a supervised questionnaire in their own homes. Clinical examinations were based on the protocol and diagnostic criteria of the UK Adult Dental Health Survey (Kelly et al., 2000, O'Sullivan et al., 2011). Thirteen dentists performed oral examinations, with participants seated on chairs and using standardised equipment (Daray light lamps, mirrors and CPI type C periodontal probes). All teeth, including third molars, were clinically examined. Participants' teeth were not brushed or professionally cleaned prior to examination, but debris and moisture were removed from individual sites with cotton wool rolls or cotton buds if visibility was obscured and probes were used for cleaning debris from the tooth surfaces to enable visual examination. Dentists examined for the presence of visible plaque, decayed, filled and missing teeth, pocket depth (PD) and loss of attachment (LOA). PD and LOA were measured at two sites per tooth (mesial and distal, with the probe aligned to the vertical axis of the tooth), buccally on upper teeth and lingually on lower teeth. PD and LOA were then recorded by tooth according to one of following five categories: 0-3, 4-5, 6-7, 8-9 or 10-11 mm. For inter-examiner reliability, examiners' assessments were individually compared with the reference examiner assessment under field circumstances. Intra-examiner reliability was not assessed. Duplicate examinations were carried out among 133 participants within a two-week interval. Kappa values were 0.57 for PD (range: 0.46-0.69) and 0.58 (range: 0.48-0.79) for LOA by tooth.

Following the clinical examination participants answered a supervised self-complete questionnaire. The questionnaire included questions on socio-demographic factors (age, gender, ethnicity, SEP and education) and oral health status. Ethnicity was self-assigned using an adaptation of the 2001 UK Census categories, which included 26 possible categories under five main ethnic groups: White, Asian, Black, Mixed or Other (Office for National Statistics, 2001). Individuals' SEP was measured by education and the National Statistics Socio-Economic Classification (NS-SEC). Education was indicated by the highest degree or qualification (no qualifications, secondary school, A levels, technical qualifications, first university degree or higher degree). NS-SEC groups were derived using the self-coded method based on current or last main job or occupation, employment status, size of

organisation and supervisory status. Five operational categories were derived: (1) managerial and professional, (2) intermediate, (3) small employers and own account workers, (4) lower supervisory and technical, and (5) semi-routine and routine occupations. For complete coverage of the population, full-time students, individuals who had never worked or were in long-term unemployment and those not classified for other reasons were added as not classified (Office for National Statistics, 2005).

Statistical analysis

We weighted the data to adjust for the unequal probability of selection, non-response and differences in the age-by-gender-by-ethnicity distribution between the sample and the general population living in the three East London boroughs included in the study, according to the UK 2001 Census (Office for National Statistics, 2001). All analyses took into account the data weighting and the complex survey design (stratification and clustering) to produce corrected standard errors and confidence intervals. Analyses were performed in STATA version 13 (StataCorp LP, College Station, TX) using the survey command.

This data analysis further excluded 341 participants due to missing data on periodontal measures (n=102), education (n=172) and socioeconomic classification (n=89). Therefore, data analysis for this sub-study included 1,925 adults. Post-hoc calculation demonstrated that the minimum sample size to provide 80% statistical power to identify an odds ratio of 1.5 and/or a risk ratio of 1.2 was estimated to be 822 (Fleiss et al., 1980). The calculation assumed 50% of the unexposed population and 60% of the exposed population to have the outcome of interest, α equal to 0.05, and β equal to 0.20.

Data manipulation was minimal. The 26 ethnic categories were regrouped to generate 12 groups: White British, East European and Other; Black African, Caribbean and Other; Asian Pakistani, Indian, Bangladeshi and Other; Mixed and Other. The White Other group included West European, Mediterranean, North and Latin America, combined because of the small numbers. Black Other included Black British, European and American, while the Asian Other included Asian British, Middle Eastern/Arabic, Chinese, and Japanese. Age was categorised into ten year brackets (mid-decade to mid-decade) to cover against possible non-linear effects. Education was re-categorised into four groups (no qualification, secondary school, A levels and higher education) and socioeconomic classification was further categorised into managerial and professional (1), intermediate (2/3), routine and manual occupations (4/5) and not classified due to small numbers in adjacent categories.

The numbers of teeth with PD≥4mm and LOA≥4mm were the outcome measures for analysis. Negative binomial regression was used to model the two outcomes as they were count variables with over-dispersion. The modelling strategy was first to estimate the crude association of ethnicity with each outcome, and then, gradually adjust for potential confounders. Following this approach, the unadjusted association between ethnicity and number of teeth with PD≥4mm was first estimated. This association was then sequentially adjusted for demographic factors (sex and age) and SEP indicators (education and socio-economic classification). At this stage, the two-way interactions (cross-products) between ethnicity and each SEP indicator were examined by assessing their statistical significance when added to the main effects model one at a time. To examine the magnitude and direction of the significant interactions, the association between ethnicity and the number of teeth with PD≥4mm was presented stratified by the SEP indicator. The same modelling strategy was followed for testing the association between ethnicity and number of teeth with LOA≥4mm.

Results

The demographic and socioeconomic characteristics of the sample are shown in Table 1. The sex, age and ethnic composition of the sample was similar to that in the three East London boroughs according to the 2011 UK Census (Office for National Statistics, 2001). In addition, there were no significant socio-demographic differences between the full ELOHI study sample (n=2,266) and the analytical sub-sample for this study (n=1,925). The mean number of teeth in the analytical sub-sample was 27.6 (SD: 4.0; range: 2-32).

Table 2 shows the periodontal disease measures according to demographic and socioeconomic characteristics. The number of teeth with PD≥4mm was significantly different among ethnic groups whereas the number of teeth with LOA≥4mm varied significantly among age groups, education level and socioeconomic classification.

Ethnic inequalities in the number of teeth with PD≥4mm persisted after adjustment for confounders. In the fully adjusted model, Asians had significantly more teeth with PD≥4mm than White British. More specifically, the number of teeth with PD≥4mm was, on average, 1.70, 1.78, 2.13 and 1.65 times higher in Pakistani, Indian, Bangladeshi and Asian Others than in White British, regardless of sociodemographic background. In addition, ethnic inequalities in the number of teeth with LOA≥4mm were identified after adjustments for sociodemographic factors. Compared to White British, the mean number of teeth with

LOA≥4mm was 1.55, 2.09 and 1.77 times higher in White Eastern Europeans, Black Africans and Bangladeshis, respectively (Table 3).

There was a significant interaction between ethnicity and education for the numbers of teeth with PD≥4mm and LOA≥4mm ($p<0.05$ in both models). However, the interaction between ethnicity and socioeconomic classification was not significant when added to either model. Stratified analysis by education groups showed that ethnic disparities in the two periodontal measures were limited to more educated groups; that is, adults with A levels and higher education for the number of teeth with PD≥4mm and those with higher education for the number of teeth with LOA≥4mm (Table 4).

Discussion

This study found large inequalities in periodontal conditions among ethnic groups living in a deprived area of the UK. Different patterns of inequalities were observed depending on the periodontal measure examined. All four Asian ethnic groups (Pakistani, Indian, Bangladeshi and Asian Others) have more teeth with periodontal pocketing whereas White East European, Black African and Bangladeshi have more teeth with attachment loss than White British. Such differences were not accounted for by sociodemographic factors. These findings are relevant because this was the first study exploring ethnic inequalities in periodontal status in a large population-based sample of adults including the three major ethnic groups living in the same area, hence sharing the same environmental factors.

Some limitations of this study need to be borne in mind when interpreting the present findings. First, this study analysed cross-sectional data which limits the ability to establish causal relationships between variables. Second, the fact that our study sample represented 85% of the adults who participated in the ELOHI study may raise some concerns about its representativeness and the effect of missing data on the results. However, we found no differences in sociodemographic composition between our study sample and the full sample of ELOHI participants, which supports the argument that missing data are unlikely to have impacted on the results and that the present findings can be generalised to the study population. Third, the twelve ethnic groups compared in this study were derived by collapsing 26 ethnic categories. Some ethnic categories included very few survey participants, producing small cell sizes and unreliable estimates. Therefore, they were collapsed into ‘other ethnic groups’. However, we assessed the main ethnic groups living in East London and the UK according to the 2011 UK Census (White British, Indian, Pakistani,

Black Caribbean and Black African) and an emerging ethnic minority (White East European). Fourth, although two periodontal sites were inspected in every tooth, only one code was recorded. Although partial-mouth assessments maximise the number of people examined in the time available and encourage subjects to comply with the study protocol, they underestimate the prevalence and severity of periodontal disease (Susin et al., 2005, Kingman et al., 2008), and may have limited our ability to identify significant differences.

The present findings demonstrate clearly that ethnic disparities between and within major ethnic groups exist. Sex-and-age-adjusted results showed significant differences between ethnic subgroups. All four Asian groups (Pakistani, Indian, Bangladeshi and Asian Others) exhibited significantly more teeth with PD≥4mm than White British. On the other hand, White East European, Black African and Asian Bangladeshi were the ethnic groups showing significantly greater numbers of teeth with LOA≥4mm than White British. The above differences would have been masked if we had collapsed ethnic categories into the three main ethnic groups. These results are in line with previous multi-country comparisons (Pilot et al., 1986, Albandar and Rams, 2002, Petersen and Ogawa, 2012) and a recent systematic review where the prevalence of severe periodontitis was higher in South Asian and African countries compared to the UK (Kassebaum et al., 2014). Nevertheless, ethnic disparities in periodontal disease, as measured by the numbers of teeth with PD≥4mm and LOA≥4mm, are likely to be due to cultural/behavioural differences rather than race (genetic make-up). Our results show significant differences in lifetime disease accumulation (loss of periodontal attachment) between White sub-groups exposed to the same environmental risks. White East Europeans had 55% more teeth with LOA≥4mm than White British. Such a difference within the same race strongly suggests that differences in periodontal measures may be explained by other factors. This is in addition to the fact that not all Black groups (Caribbean and Others) had greater attachment loss than White British.

This study also supports the complex interrelationship between ethnicity, SEP and periodontal disease. On one hand, education and socioeconomic classification explained very little of the association between ethnicity and periodontal measures, as indicated by the percent attenuation in the rate ratios for ethnic groups after adjustment for SEP measures. This was in addition to restricting the sample to a deprived area, which provided an additional control for SEP during the study design as all participants were generally exposed to similar social and environmental circumstances. On the other hand, we found evidence of a positive interaction between education and ethnicity, whereby ethnic differences were significant

among more educated groups only. This finding may reflect the strong effect of material deprivation that blurs any advantage White British may have over other ethnic groups among less educated people. It is only at higher levels of education that White British have better periodontal health than other ethnic groups, probably due to better access and uptake of health education messages. Perhaps, the most important message coming out from these findings is that SEP explains partially but not fully ethnic disparities in periodontal health, suggesting that other factors may also underlie that relationship. Prior research has shown that culture, social norms and acculturation among immigrants (Cruz et al., 2009, Sanders, 2010); health-related behaviours (Borrell et al., 2003, Craig et al., 2001); attitudes towards and delivery of dental health care services (Gilbert, 2005, Gilbert et al., 2006); racial harassment and discrimination (Cabral et al., 2005); psychosocial stress (Borrell et al., 2003, Watson et al., 2008, Borrell and Crawford, 2011) and community characteristics (Borrell et al., 2004b) are related to ethnicity and oral health. However, the contribution of those factors to explain ethnic inequalities in oral health has not been formally assessed. Further studies should explore the relative roles of different factors, which may help to identify those more amenable to intervention so as to reduce ethnic inequalities in adult oral health.

To conclude, this study showed considerable ethnic disparities in periodontal disease among adults in East London. Compared to White British, all Asians groups (Pakistani, Indian, Bangladeshi and Asian Others) exhibited more teeth with periodontal pocketing. In addition, White East European, Black African and Bangladeshi had more teeth with periodontal attachment loss. These differences were over and above the effect of demographic and socioeconomic factors. Further studies should explore the contribution of other factors to explain ethnic inequalities in periodontal disease.

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Table 1. Characteristics of the ELOHI sample (n=1925) and comparison with the general adult population in the three East London boroughs

Characteristics	Study population		Sample	
	n	(%)	n[a]	(%)
Sex				
Men	196,120	(48.8)	613	(48.8)
Women	205,434	(51.2)	1312	(51.2)
Age groups				
16-24 years	73,803	(18.4)	161	(17.1)
25-34 years	105,876	(26.4)	713	(25.0)
35-44 years	95,594	(23.8)	717	(25.1)
45-54 years	72,943	(18.2)	200	(19.3)
55-65 years	53,338	(13.3)	134	(13.5)
Ethnicity				
White British	246,231	(61.3)	533	(53.7)
White East European	9,709	(2.4)	63	(5.2)
White Others	21,355	(5.3)	85	(8.5)
Black African	18,492	(4.6)	274	(4.8)
Black Caribbean	21,239	(5.3)	84	(1.8)
Black Other	2,805	(0.7)	131	(2.7)
Pakistani	21,712	(5.7)	198	(5.8)
Indian	31,301	(7.8)	112	(3.3)
Bangladeshi	4,498	(1.1)	69	(1.8)
Asian Other	9,020	(2.2)	314	(9.0)
Mixed	7,265	(1.8)	28	(1.8)
Other	6,921	(1.7)	34	(1.7)
Education				
No qualification	127,692	(31.8)	175	(12.7)
Secondary school	70,672	(17.6)	457	(26.7)
A levels	116,047	(28.9)	496	(25.7)
Higher education	87,136	(21.7)	797	(35.0)
Socio-economic classification				
Managerial/professional	120,010	(29.8)	809	(42.8)
Intermediate	80,332	(20.0)	299	(16.8)
Routine/manual	104,211	(26.0)	385	(23.1)
Not classified	97,011	(24.2)	432	(17.3)

[a] Counts are unweighted

Table 2. Periodontal disease measures by demographic and socioeconomic characteristics among 16-65-year-old adults from East London (n=1925)

Characteristics	Number of teeth		Number of teeth with PD≥4mm		Number of teeth with LOA≥4mm	
	Mean	**[95% CI]**	**Mean**	**[95% CI]**	**Mean**	**[95% CI]**
Ethnic groups						
White British	27.04	[26.56-27.52]	10.07	[8.80-11.34]	3.81	[3.19-4.44]
White East European	28.06	[27.22-28.91]	11.14	[8.53-13.75]	5.04	[3.15-6.93]
White Other	25.44	[23.84-27.04]	7.69	[5.52-9.86]	4.54	[2.96-6.12]
Black African	30.30	[30.01-30.59]	10.39	[8.98-11.81]	4.28	[3.27-5.29]
Black Caribbean	28.74	[27.66-29.83]	10.76	[7.72-13.80]	3.19	[1.95-4.42]
Black Other	28.67	[27.60-29.73]	8.28	[6.71-9.84]	3.22	[2.15-4.29]
Asian Pakistani	29.66	[29.12-30.20]	15.16	[12.68-17.63]	3.89	[2.69-5.09]
Asian Indian	29.31	[28.65-29.96]	16.87	[13.87-19.87]	4.50	[2.52-6.48]
Asian Bangladeshi	29.55	[28.85-30.25]	19.12	[15.76-22.48]	4.14	[2.42-5.87]
Asian Other	28.75	[28.39-29.12]	15.82	[14.26-17.39]	3.43	[2.52-4.34]
Mixed	28.47	[27.17-29.77]	6.04	[3.55-8.53]	1.53	[0.63-2.49]
Other	28.88	[27.59-30.16]	13.12	[7.55-18.70]	2.59	[0.57-4.60]
P value[a]	*<0.001*		*<0.001*		*0.128*	
Sex						
Men	27.92	[27.42-28.42]	11.94	[10.74-13.14]	3.78	[3.07-4.49]
Women	27.44	[27.09-27.78]	11.58	[10.24-12.93]	4.30	[3.45-5.15]
P value[a]	*0.101*		*0.158*		*0.073*	
Age group						
16-24 years	28.96	[28.43-29.49]	9.12	[5.95-12.28]	0.87	[0.43-1.32]
25-34 years	29.08	[28.79-29.37]	11.94	[10.75-13.12]	3.50	[2.71-4.28]
35-44 years	28.47	[28.24-28.69]	10.93	[9.92-11.93]	3.22	[2.76-3.68]
45-54 years	26.53	[25.75-27.31]	11.36	[9.80-12.92]	5.56	[4.60-6.53]
55-65 years	28.96	[28.43-29.49]	11.88	[10.05-13.71]	7.15	[5.75-8.55]
P value for trend[a]	*<0.001*		*0.269*		*<0.001*	
Education						
No qualification	26.74	[25.46-28.02]	11.56	[8.02-15.09]	4.72	[3.21-6.25]
Secondary school	27.11	[26.45-27.76]	10.20	[8.92-11.48]	3.58	[2.82-4.35]
A levels	27.45	[26.78-28.13]	12.01	[10.79-13.22]	5.15	[4.27-6.04]
Higher education	28.59	[28.32-28.87]	10.90	[9.79-12.01]	2.83	[2.35-3.32]
P value for trend[a]	*<0.001*		*0.920*		*0.018*	
Socio-economic classification						
Managerial/professional	27.82	[27.43-28.22]	10.60	[9.59-11.61]	3.52	[3.01-4.04]
Intermediate	27.10	[26.21-28.00]	11.75	[10.33-13.17]	4.83	[3.79-5.86]
Routine/manual	27.42	[26.63-28.21]	12.02	[9.95-14.09]	4.55	[3.54-5.56]
P value for trend[a]	*0.281*		*0.181*		*0.035*	

PD: pocket depth; LOA: loss of attachment

[a] Negative binomial regression was used for comparison. P values correspond to omnibus tests for any difference between groups or for tests for linear trends.

Table 3. Models for ethnic differences in number of teeth with probing pocket depth (PD)≥4mm and loss of attachment (LOA)≥4mm among 16-65-year-old adults from East London (n=1925)

Outcome	Ethnic groups	Model 1[a]		Model 2		Model 3	
		RR[b]	[95% CI]	RR	[95% CI]	RR	[95% CI]
PD	White British	1.00	[Reference]	1.00	[Reference]	1.00	[Reference]
	White East European	1.11	[0.85-1.44]	1.08	[0.82-1.42]	1.03	[0.78-1.35]
	White Other	0.76	[0.56-1.04]	0.78	[0.56-1.07]	0.77	[0.57-1.04]
	Black African	1.03	[0.86-1.25]	1.08	[0.85-1.37]	1.11	[0.89-1.38]
	Black Caribbean	1.07	[0.78-1.46]	1.09	[0.81-1.47]	1.13	[0.83-1.53]
	Black Other	0.82	[0.65-1.03]	0.83	[0.65-1.05]	0.83	[0.67-1.05]
	Asian Pakistani	1.51	[1.22-1.86]***	1.61	[1.21-2.14]**	1.70	[1.29-2.23]***
	Asian Indian	1.68	[1.34-2.09]***	1.67	[1.32-2.10]***	1.78	[1.40-2.26]***
	Asian Bangladeshi	1.90	[1.53-2.36]***	2.00	[1.49-2.68]***	2.13	[1.62-2.80]***
	Asian Other	1.57	[1.33-1.85]***	1.65	[1.34-2.02]***	1.65	[1.37-1.98]***
	Mixed	0.60	[0.39-0.92]*	0.64	[0.41-0.99]*	0.65	[0.42-1.01]
	Other	1.30	[0.84-2.03]	1.28	[0.84-1.95]	1.32	[0.84-2.07]
LOA	White British	1.00	[Reference]	1.00	[Reference]	1.00	[Reference]
	White East European	1.32	[0.88-1.99]	1.67	[1.07-2.61]*	1.55	[1.01-2.38]*
	White Other	1.19	[0.82-1.74]	1.20	[0.82-1.77]	1.28	[0.90-1.83]
	Black African	1.12	[0.84-1.50]	1.85	[1.26-2.72]**	2.09	[1.40-3.12]***
	Black Caribbean	0.84	[0.55-1.27]	0.93	[0.63-1.38]	1.06	[0.70-1.62]
	Black Other	0.84	[0.58-1.22]	1.09	[0.66-1.81]	1.32	[0.71-2.46]
	Asian Pakistani	1.02	[0.72-1.45]	1.38	[0.87-2.21]	1.51	[0.93-2.45]
	Asian Indian	1.18	[0.74-1.89]	1.07	[0.75-1.54]	1.29	[0.85-1.96]
	Asian Bangladeshi	1.09	[0.69-1.70]	1.37	[0.85-2.21]	1.77	[1.01-3.10]*
	Asian Other	0.90	[0.66-1.23]	1.12	[0.75-1.65]	1.14	[0.76-1.72]
	Mixed	0.41	[0.22-0.76]**	0.89	[0.32-2.44]	0.89	[0.32-2.49]
	Other	0.68	[0.31-1.51]	0.93	[0.42-2.04]	0.88	[0.41-1.89]

[a] Model 1 was unadjusted; Model 2 adjusted for demographic factors (sex and age groups); Model 3 additionally adjusted for socioeconomic position (education and socioeconomic classification).

[b] Negative binomial regression models were fitted and rate ratios (RR) reported.

Table 4. Ethnic disparities in numbers of teeth with probing pocket depth (PD)≥4mm and loss of attachment (LOA)≥4mm among 16-65-year-old adults from East London with similar levels of education (n=1,925)

Outcome	Ethnic group	All sample		No qualification		Secondary school		A levels		Higher education	
		Mean[a]	[95% CI]	Mean[a]	[95% CI]	Mean[a]	[95% CI]	Mean[a]	[95% CI]	Mean[a]	[95% CI]
PD	White British	9.6	[8.3-10.8]	13.0	[7.1-18.9]	9.6	[7.9-11.4]	10.1	[8.1-12.1]	8.1	[6.2-10.0]
	White East European	8.5	[6.3-10.8]	14.5	[10.7-18.4]	3.9	[0.9-6.8]	10.9	[7.8-14.1]	10.7	[6.1-15.2]
	White Other	7.2	[5.5-9.0]	3.4	[1.5-5.3]	10.0	[5.1-15.0]	12.3	[8.3-16.3]	5.0	[2.6-7.5]
	Black African	10.9	[9.2-12.5]	11.5	[7.3-15.8]	12.5	[8.0-17.1]	10.2	[7.1-13.3]	9.9	[8.3-11.5]
	Black Caribbean	11.2	[8.8-13.6]	11.4	[8.3-14.5]	14.3	[9.4-19.2]	8.0	[4.5-11.4]	11.8	[7.0-16.5]
	Black Others	7.5	[5.8-9.2]	3.5	[0.7-7.6]	7.3	[4.1-10.5]	11.7	[8.5-14.9]	7.4	[5.6-9.3]
	Pakistani	14.9	[11.9-17.9]	13.0	[9.8-16.2]	11.0	[6.9-15.2]	16.3	[9.5-23.0]	18.5	[13.9-23.0]
	Indian	15.1	[12.1-18.1]	13.2	[4.9-21.5]	9.7	[6.0-13.3]	20.2	[12.2-28.2]	18.1	[14.5-21.8]
	Bangladeshi	19.1	[15.9-22.2]	15.4	[9.7-21.1]	26.4	[17.4-35.4]	16.4	[10.6-22.2]	18.0	[14.2-21.8]
	Asian Others	15.1	[13.4-16.9]	10.6	[6.4-14.8]	12.5	[9.3-15.7]	18.9	[15.1-22.6]	17.0	[14.3-19.8]
	Mixed	6.8	[4.2-9.4]	3.2	[0.6-5.7]	5.2	[1.0-9.4]	11.1	[4.7-17.6]	7.7	[2.0-13.5]
	Other	10.5	[7.8-13.2]	3.7	[0.7-6.7]	9.5	[4.2-14.8]	10.6	[5.9-15.4]	16.9	[10.7-23.1]
LOA	White British	2.7	[2.1-3.3]	3.5	[2.0-5.0]	2.5	[1.8-3.3]	4.1	[2.7-5.4]	1.9	[1.1-2.7]
	White East European	2.6	[1.2-4.0]	5.5	[0.5-10.4]	0.6	[0.0-1.5]	6.8	[3.2-10.5]	3.2	[1.6-4.8]
	White Other	3.3	[2.1-4.4]	2.4	[0.3-4.5]	3.4	[0.9-6.0]	4.6	[1.2-7.9]	2.7	[1.5-4.0]
	Black African	5.1	[3.5-6.8]	2.4	[0.2-4.5]	5.6	[1.4-9.7]	7.5	[2.6-12.4]	4.9	[3.1-6.7]
	Black Caribbean	2.8	[1.9-3.7]	2.8	[0.0-5.6]	2.9	[1.5-4.3]	1.8	[0.6-3.0]	3.7	[1.9-5.5]
	Black Others	2.4	[1.2-3.7]	0.3	[0.0-1.0]	3.0	[1.5-4.4]	3.0	[1.0-5.0]	4.0	[0.0-8.0]
	Pakistani	4.4	[2.6-6.1]	10.6	[1.1-22.3]	6.8	[0.0-14.3]	4.0	[1.9-6.0]	2.3	[1.2-3.4]
	Indian	3.2	[2.1-4.3]	2.6	[0.1-6.4]	4.2	[1.2-7.2]	3.3	[1.1-5.4]	2.7	[1.4-4.1]
	Bangladeshi	3.5	[1.8-5.2]	1.7	[0.0-3.5]	3.2	[1.0-5.4]	3.1	[0.1-7.3]	5.7	[2.0-9.4]
	Asian Others	3.1	[2.1-4.1]	2.6	[0.3-4.9]	5.6	[0.1-11.1]	3.0	[1.9-4.1]	2.2	[1.4-2.9]
	Mixed	2.4	[0.6-4.1]	1.2	[0.1-2.3]	4.4	[0.0-13.5]	5.8	[0.5-11.2]	1.0	[0.0-2.2]
	Other	2.3	[0.5-4.0]	2.0	[0.0-5.5]	2.6	[0.9-6.1]	6.4	[1.7-11.2]	1.0	[0.0-2.7]

[a] Predicted values derived from negative binomial regression models including sex, age groups, ethnicity, socioeconomic classification, education and the interaction between education and ethnicity as explanatory variables.
Grey cells indicate differences between that ethnic group and White British with the same level of education